

**What is claimed is:**

1. A failure detection apparatus for an internal combustion engine, comprising:

5 fresh air quantity detecting means arranged in an intake system of the engine, for detecting a quantity of fresh air introduced into a combustion chamber of the engine;

10 fresh air quantity reference value setting means for setting a reference value for the fresh air quantity in accordance with an operating state of the engine;

failure detecting means for detecting abnormality of said fresh air quantity detecting means, based on a result of comparison between the fresh air quantity detected by  
15 said fresh air quantity detecting means and the reference value set by said fresh air quantity reference value setting means;

20 exhaust flow rate adjusting means arranged in at least one of the intake system and exhaust system of the engine, for adjusting an exhaust flow rate;

target adjustment setting means for setting a target adjustment amount for said exhaust flow rate adjusting means in accordance with the operating state of the engine such that an air-fuel ratio or excess air ratio of the  
25 exhaust system becomes equal to a predetermined value corresponding to the operating state; and

30 exhaust flow rate control means for controlling said exhaust flow rate adjusting means in accordance with the target adjustment amount set by said target adjustment setting means,

wherein said fresh air quantity reference value setting means sets the reference value in accordance with not only the operating state of the engine but also the

target adjustment amount set for said exhaust flow rate adjusting means by said target adjustment setting means.

2. The failure detection apparatus according to claim 1, wherein said exhaust flow rate adjusting means includes  
5 at least one of an intake throttle valve arranged in the intake system for adjusting the fresh air quantity and an exhaust throttle valve arranged in the exhaust system for directly adjusting the exhaust flow rate, and

10 said fresh air quantity reference value setting means sets the reference value in accordance with not only the operating state of the engine but also a target valve opening set for said at least one of the intake and exhaust throttle valves by said target adjustment setting means.

3. The failure detection apparatus according to claim 15 1, further comprising exhaust concentration detecting means for detecting an exhaust concentration to thereby detect the air-fuel ratio or excess air ratio of the exhaust system,

20 wherein said fresh air quantity reference value setting means corrects the target adjustment amount for said exhaust flow rate adjusting means, based on a difference between the air-fuel ratio or excess air ratio of the exhaust system, detected by said exhaust concentration detecting means, and the predetermined value,  
25 and sets the reference value based on the corrected target adjustment amount.

4. The failure detection apparatus according to claim 1, further comprising exhaust concentration detecting means for detecting an exhaust concentration to thereby detect  
30 the air-fuel ratio or excess air ratio of the exhaust system,

wherein said exhaust flow rate control means corrects an amount of adjustment by said exhaust flow rate adjusting

means such that the air-fuel ratio or excess air ratio of the exhaust system, detected by said exhaust concentration detecting means, coincides with the predetermined value.

5 1. The failure detection apparatus according to claim 1, further comprising exhaust concentration detecting means for detecting an exhaust concentration to thereby detect the air-fuel ratio or excess air ratio of the exhaust system,

10 wherein, when the air-fuel ratio or excess air ratio of the exhaust system, detected by said exhaust concentration detecting means, is different from the predetermined value, said fresh air quantity reference value setting means suspends the control of said exhaust flow rate adjusting means by said exhaust flow rate control  
15 means and sets the reference value based solely on the operating state of the engine.

6. A failure detection apparatus for an internal combustion engine, comprising:

20 fresh air quantity detecting means arranged in an intake system of the engine, for detecting a quantity of fresh air introduced into a combustion chamber of the engine;

25 fresh air quantity reference value setting means for setting a reference value for the fresh air quantity in accordance with an operating state of the engine;

30 failure detecting means for detecting abnormality of said fresh air quantity detecting means, based on a result of comparison between the fresh air quantity detected by said fresh air quantity detecting means and the reference value set by said fresh air quantity reference value setting means;

exhaust flow rate adjusting means arranged in one of the intake system and exhaust system of the engine, for

adjusting an exhaust flow rate;

target adjustment setting means for setting a target adjustment amount for said exhaust flow rate adjusting means in accordance with the operating state of the engine such that an air-fuel ratio or excess air ratio of the exhaust system becomes equal to a predetermined value corresponding to the operating state;

exhaust flow rate control means for controlling said exhaust flow rate adjusting means in accordance with the target adjustment amount set by said target adjustment setting means;

an EGR passage for allowing part of exhaust gas to be recirculated from the exhaust system of the engine to the intake system as EGR gas;

an EGR valve inserted in said EGR passage, for controlling a quantity of the EGR gas by varying an opening thereof;

target opening setting means for setting a target EGR valve opening for said EGR valve in accordance with the operating state of the engine such that the air-fuel ratio or excess air ratio of the exhaust system becomes equal to the predetermined value; and

EGR valve control means for controlling said EGR valve in accordance with the target EGR valve opening set by said target opening setting means,

wherein said fresh air quantity reference value setting means sets the reference value in accordance with not only the operating state of the engine but also the target adjustment amount set for said exhaust flow rate adjusting means by said target adjustment setting means and the target EGR valve opening set by said target opening setting means.

7. The failure detection apparatus according to claim

6, wherein said exhaust flow rate adjusting means includes at least one of an intake throttle valve arranged in the intake system for adjusting the fresh air quantity and an exhaust throttle valve arranged in the exhaust system for  
5 directly adjusting the exhaust flow rate, and

    said fresh air quantity reference value setting means sets the reference value in accordance with not only the operating state of the engine but also a target valve opening set for said at least one of the intake and exhaust  
10 throttle valves by said target adjustment setting means and the target EGR valve opening set by said target opening setting means.

8. The failure detection apparatus according to claim 6, further comprising exhaust concentration detecting means  
15 for detecting an exhaust concentration to thereby detect the air-fuel ratio or excess air ratio of the exhaust system,

    wherein said fresh air quantity reference value setting means corrects at least one of the target  
20 adjustment amount and the target EGR valve opening based on a difference between the air-fuel ratio or excess air ratio of the exhaust system, detected by said exhaust concentration detecting means, and the predetermined value, and sets the reference value based on said at least one of  
25 the corrected target adjustment amount and the corrected target EGR valve opening.

9. The failure detection apparatus according to claim 6, further comprising exhaust concentration detecting means  
30 for detecting an exhaust concentration to thereby detect the air-fuel ratio or excess air ratio of the exhaust system,

    wherein said exhaust flow rate control means corrects an amount of adjustment by said exhaust flow rate adjusting

means such that the air-fuel ratio or excess air ratio of the exhaust system, detected by said exhaust concentration detecting means, coincides with the predetermined value, and

5        said EGR valve control means corrects the opening of said EGR valve such that the air-fuel ratio or excess air ratio of the exhaust system, detected by said exhaust concentration detecting means, coincides with the predetermined value.

10        10. The failure detection apparatus according to claim 6, further comprising exhaust concentration detecting means for detecting an exhaust concentration to thereby detect the air-fuel ratio or excess air ratio of the exhaust system,

15        wherein, when the air-fuel ratio or excess air ratio of the exhaust system, detected by said exhaust concentration detecting means, is different from the predetermined value, said fresh air quantity reference value setting means suspends the control of said exhaust  
20 flow rate adjusting means by said exhaust flow rate control means as well as the control of said EGR valve by said EGR valve control means and sets the reference value based solely on the operating state of the engine.

25        11. A failure detection method implemented by a failure detection apparatus for an internal combustion engine, the failure detection apparatus including fresh air quantity detecting means for detecting a quantity of fresh air introduced into a combustion chamber of the engine and exhaust flow rate adjusting means for adjusting an exhaust  
30 flow rate in at least one of intake and exhaust systems of the engine, said failure detection method comprising:

      a target adjustment setting step of setting a target adjustment amount for the exhaust flow rate adjusting means

in accordance with an operating state of the engine such that an air-fuel ratio or excess air ratio of the exhaust system becomes equal to a predetermined value corresponding to the operating state;

5        an exhaust flow rate control step of controlling the exhaust flow rate adjusting means in accordance with the target adjustment amount set in said target adjustment setting step;

10        a fresh air quantity reference value setting step of setting a reference value for the fresh air quantity in accordance with the operating state of the engine and the target adjustment amount set for the exhaust flow rate adjusting means in said target adjustment setting step; and

15        a failure detecting step of detecting abnormality of the fresh air quantity detecting means, based on a result of comparison between the fresh air quantity detected by the fresh air quantity detecting means and the reference value set in said fresh air quantity reference value setting step.

20        12. The failure detection method according to claim 11, wherein said exhaust flow rate adjusting means includes at least one of an intake throttle valve arranged in the intake system for adjusting the fresh air quantity and an exhaust throttle valve arranged in the exhaust system for  
25 directly adjusting the exhaust flow rate, and

      said fresh air quantity reference value setting step comprises setting the reference value in accordance with not only the operating state of the engine but also a target valve opening set for said at least one of the  
30 intake and exhaust throttle valves in said target adjustment setting step.

      13. The failure detection method according to claim 11, wherein said failure detection apparatus further

includes exhaust concentration detecting means for detecting an exhaust concentration to thereby detect the air-fuel ratio or excess air ratio of the exhaust system, and

5        said fresh air quantity reference value setting step comprises correcting the target adjustment amount for the exhaust flow rate adjusting means based on a difference between the air-fuel ratio or excess air ratio of the exhaust system, detected by the exhaust concentration  
10 detecting means, and the predetermined value, and setting the reference value based on the corrected target adjustment amount.

14. The failure detection method according to claim 11, wherein said failure detection apparatus further  
15 includes exhaust concentration detecting means for detecting an exhaust concentration to thereby detect the air-fuel ratio or excess air ratio of the exhaust system, and

      said exhaust flow rate control step comprises  
20 correcting an amount of adjustment by the exhaust flow rate adjusting means such that the air-fuel ratio or excess air ratio of the exhaust system, detected by the exhaust concentration detecting means, coincides with the predetermined value.

25        15. The failure detection method according to claim 11, wherein said failure detection apparatus further includes exhaust concentration detecting means for detecting an exhaust concentration to thereby detect the air-fuel ratio or excess air ratio of the exhaust system,  
30 and

      if the air-fuel ratio or excess air ratio of the exhaust system, detected by the exhaust concentration detecting means, is different from the predetermined value,



said fresh air quantity reference value setting step  
suspends the control of the exhaust flow rate adjusting  
means in said exhaust flow rate control step and sets the  
reference value based solely on the operating state of the  
5 engine.

16. A failure detection method implemented by a  
failure detection apparatus for an internal combustion  
engine, the failure detection apparatus including fresh air  
quantity detecting means for detecting a quantity of fresh  
10 air introduced into a combustion chamber of the engine,  
exhaust flow rate adjusting means for adjusting an exhaust  
flow rate in at least one of intake and exhaust systems of  
the engine, an EGR passage for allowing part of exhaust gas  
to be recirculated from the exhaust system of the engine to  
15 the intake system as EGR gas, and an EGR valve inserted in  
the EGR passage for controlling a quantity of the EGR gas  
by varying an opening thereof, said failure detection  
method comprising:

a target adjustment setting step of setting a target  
20 adjustment amount for the exhaust flow rate adjusting means  
in accordance with an operating state of the engine such  
that an air-fuel ratio or excess air ratio of the exhaust  
system becomes equal to a predetermined value corresponding  
to the operating state;

25 an exhaust flow rate control step of controlling the  
exhaust flow rate adjusting means in accordance with the  
target adjustment amount set in said target adjustment  
setting step;

a target opening setting step of setting a target EGR  
30 valve opening for the EGR valve in accordance with the  
operating state of the engine such that the air-fuel ratio  
or excess air ratio of the exhaust system becomes equal to  
the predetermined value;

an EGR valve control step of controlling the EGR valve in accordance with the target EGR valve opening set in said target opening setting step;

5 a fresh air quantity reference value setting step of setting a reference value for the fresh air quantity in accordance with the operating state of the engine, the target adjustment amount set for the exhaust flow rate adjusting means in said target adjustment setting step, and the target EGR valve opening set in said target opening  
10 setting step; and

a failure detecting step of detecting abnormality of the fresh air quantity detecting means, based on a result of comparison between the fresh air quantity detected by the fresh air quantity detecting means and the reference  
15 value set in said fresh air quantity reference value setting step.

17. The failure detection method according to claim 16, wherein the exhaust flow rate adjusting means includes at least one of an intake throttle valve arranged in the  
20 intake system for adjusting the fresh air quantity and an exhaust throttle valve arranged in the exhaust system for directly adjusting the exhaust flow rate, and

said fresh air quantity reference value setting step comprises setting the reference value in accordance with  
25 not only the operating state of the engine but also a target valve opening set for said at least one of the intake and exhaust throttle valves in said target adjustment setting step and the target EGR valve opening set in said target opening setting step.

30 18. The failure detection method according to claim 16, wherein said failure detection apparatus further includes exhaust concentration detecting means for detecting an exhaust concentration to thereby detect the

air-fuel ratio or excess air ratio of the exhaust system,  
and

5       said fresh air quantity reference value setting step  
comprises correcting at least one of the target adjustment  
amount and the target EGR valve opening based on a  
difference between the air-fuel ratio or excess air ratio  
of the exhaust system, detected by the exhaust  
concentration detecting means, and the predetermined value,  
and setting the reference value based on said at least one  
10 of the corrected target adjustment amount and the corrected  
target EGR valve opening.

19. The failure detection method according to claim  
16, wherein said failure detection apparatus further  
includes exhaust concentration detecting means for  
15 detecting an exhaust concentration to thereby detect the  
air-fuel ratio or excess air ratio of the exhaust system,

      said exhaust flow rate control step comprises  
correcting an amount of adjustment by the exhaust flow rate  
adjusting means such that the air-fuel ratio or excess air  
20 ratio of the exhaust system, detected by the exhaust  
concentration detecting means, coincides with the  
predetermined value, and

      said EGR valve control step comprises correcting the  
opening of the EGR valve such that the air-fuel ratio or  
25 excess air ratio of the exhaust system, detected by the  
exhaust concentration detecting means, coincides with the  
predetermined value.

20. The failure detection method according to claim  
16, wherein said failure detection apparatus further  
30 includes exhaust concentration detecting means for  
detecting an exhaust concentration to thereby detect the  
air-fuel ratio or excess air ratio of the exhaust system,  
and

if the air-fuel ratio or excess air ratio of the exhaust system, detected by the exhaust concentration detecting means, is different from the predetermined value, said fresh air quantity reference value setting step

5 suspends the control of the exhaust flow rate adjusting means in said exhaust flow rate control step as well as the control of the EGR valve in said EGR valve control step and sets the reference value based solely on the operating state of the engine.